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**Intermountain
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Research Paper
INT-466

June 1993

Problems in Lodgepole Pine Thinnings: Basal Live Limbs and Fill-in Regeneration

Dennis M. Cole

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THE AUTHOR

DENNIS M. COLE is research silviculturist at the Intermountain Research Station, Forestry Sciences Laboratory, Bozeman, MT. His studies have focused on lodgepole pine silviculture, particularly growth and yield relationships, stand culture and development, and silvicultural practices for reducing insect and disease problems.

RESEARCH SUMMARY

Leaders that develop from live limbs left on stumps in thinning operations must be removed if thinning goals are to be fully realized. A linear regression model was developed to relate the height of the lowest live limbs of lodgepole pine trees to their age and height, and to stand density. The model was used to prepare three-dimensional graphs showing the combinations of age, height, and stand density least likely to have live limbs within 0.5 ft of the ground. It is not practical to cut stumps lower during thinning. Fill-in regeneration (ingress) is also a problem in lodgepole pine stands thinned too early, or with spacings that are too wide.

At locations on four National Forests in western Montana and eastern Idaho, fill-in regeneration was counted over a 17-year period following thinnings to five spacing levels. The amount of lodgepole pine ingress increased with spacing level. However, during the last 6 years of the study, seedling establishment decreased at the narrowest spacing (6 by 6 ft) and increased at the widest (18 by 18 ft).

Management guidelines based on the study are:

1. If lodgepole pine stands are thinned before age 16, or to spacings much wider than 9 by 9 ft, they probably will have to be cleaned of live branches remaining on the stumps and of fill-in regeneration over the next 15 to 20 years. Otherwise, the thinning's growth and yield objectives aren't likely to be achieved.
2. To avoid increased costs in dealing with live limbs left on the stump, most lodgepole pine stands shouldn't be thinned before they are 16 years old, unless they have more than 10,000 to 15,000 trees per acre. Most stands shouldn't be thinned before they are 12 years old, unless they have more than 15,000 to 20,000 trees per acre. For each age threshold, the lower stocking level would apply to the poorest sites and the higher stocking level to the best sites.
3. To minimize problems from live limbs left on the stump and to benefit wildlife cover without unduly reducing growth and yield, thinning can be done in two steps: (1) an initial thinning to 6- to 7-ft average spacing at 12 or 16 years old, depending on stocking and site index; (2) a second thinning about 15 to 25 years later to average spacing of 12 to 14 ft.

Intermountain Research Station
324 25th Street
Ogden, UT 84401

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INTRODUCTION

The inland form of lodgepole pine (*Pinus contorta* var. *latifolia*) typically regenerates too abundantly, due to its ability to exploit burned or mechanically disturbed sites with seed stored in serotinous cones (cones that stay closed until they are heated). When stands are only slightly overstocked, the growth of individual trees may be only slightly retarded, particularly when the trees are young. Since trees fully occupy the site, the site may be producing the most wood possible then. However, as the stand becomes older and denser, tree growth slows and the stand may stagnate. To preclude stagnation or minimize growth and yield losses, forest managers have thinned regenerated lodgepole pine stands at very young ages—sometimes as early as 8 to 10 years. Some early thinnings have been successful, but two problems sometimes occur: (1) live limbs left on stumps develop into leaders, and (2) seedlings continue to establish in stands thinned to wider spacings.

The problem of leaders developing on stumps usually occurs when overstocking is moderate and basal limbs have not yet begun to die at the time of thinning. In the absence of formal guidelines, forest managers have dealt with this problem in different ways with varying degrees of success. Sometimes, the height of the lowest live limbs is monitored and thinning is delayed until the lowest limbs are likely to be above the stumps left after thinning. There is then no need to look for live limbs that might have been left on stumps. In many cases, however, a thinning age that worked well in one area is tried in another—with poor results. The problem is further complicated when the thinning is done by contract. Contracts require clear and attainable specifications. The issues of stump heights and severing of limbs from stumps have been major factors in increasing bid costs. Site factors, such as ground slope and rockiness, and the type, height, and density of vegetation determine the time required to find and cut basal live limbs, significantly influencing contract bid prices for thinning. Bids would probably be lower if basal live limbs were not a factor. Therefore, managers could benefit if they knew when basal limbs would be above the height of stumps left after thinning.

Fill-in stocking from continuing seedling establishment also is a problem after thinning, but one not as easily recognized. Non-serotinous cones in adjacent seedwalls (trees serving as a seed source) can provide seed, and regenerated saplings themselves may begin producing viable seed at 5 to 10 years of age (Lotan and Critchfield 1990). Therefore, seedlings can become established over a number of years in areas opened by thinning, seriously compromising spacing objectives.

Obviously, the problems of unwanted leaders and unwanted seedlings are related to stand density and age. This paper investigates these relationships, offering guidelines for appropriate stand ages and spacings for successful thinnings in selected areas of western Montana and eastern Idaho.

METHODS

The basal live limbs problem and the problem of fill-in regeneration were each addressed with a separate study.

Basal Live Limbs Study

Data were obtained from 94 randomly selected lodgepole pine saplings in three young, naturally regenerated stands in the Squaw Creek drainage of the Gallatin National Forest. The stands are in the *Abies lasiocarpa/Vaccinium scoparium* ecological habitat type (Pfister and others 1977). The study area is about 20 airline miles south of Bozeman, MT at elevations of 6,500 to 7,000 ft above sea level. Ages of the trees measured ranged from 9 to 32 years. Measurements taken on the sample trees were total height, height to the lowest live limb, and tree age. Tree height was measured to the nearest 0.1 ft with a measuring rod. Height to the lowest live limb was measured in units of 0.01 ft. Age was determined by counting the annual rings on stumps cut 1 inch above the ground after height was measured. The stand density affecting each measured sample tree was determined by counting the number of seedlings and saplings on a $^1/_{1000}$-acre plot (radius = 3.72 ft), centered on the subject tree.

Variances in the height to the lowest live limb computed for each stand were found to be of no significant

difference (Chi-square, $p > 0.25$); therefore, stand data were pooled for analysis. A linear regression model was fitted to the pooled data to relate the height to the lowest live limb to the other variables measured.

Fill-in Regeneration Study

Data on fill-in stocking in young stands were obtained from a long-term study of five spacing levels in lodgepole pine. The study locations in western Montana and eastern Idaho were: the Gallatin, Lewis and Clark, and Kootenai National Forests in Montana, and the Targhee National Forest in Idaho (fig. 1). Ecological habitat types represented at the Montana locations (Pfister and others 1977) and the Idaho location (Steele and others 1983), were:

1. A transition between the *Abies lasiocarpa/Calamagrostis canadensis* habitat type and the *Abies lasiocarpa/Vaccinium scoparium* habitat type, *Calamagrostis rubescens* phase, Lewis and Clark National Forest.
2. The *Abies lasiocarpa-Pinus albicaulis/Vaccinium scoparium* habitat type, Gallatin National Forest.
3. The *Thuja plicata/Clintonia uniflora* habitat type, Kootenai National Forest.
4. The *Pseudotsuga menziesii/Calamagrostis rubescens* habitat type, Targhee National Forest.

In each case, permanent plots for five spacing levels were established within 7- to 10-year-old naturally regenerated clearcuts. Lodgepole pine regeneration established after spacing was accomplished was counted for the periods 1976 to 1985 and 1986 to 1991 in the Lewis and Clark, Gallatin, and Targhee National Forest spacing plots. Regeneration established between 1976 and 1985 was removed in 1985 at these locations. Regeneration established in the Kootenai National Forest spacing plots was allowed to accumulate from 1976 to 1991. Plot regeneration counts were converted to trees per acre and summarized for tabular analysis.

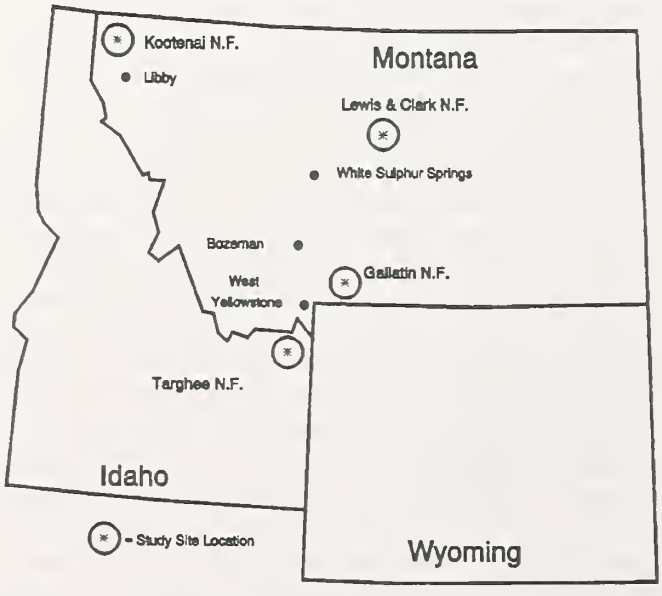

Figure 1—Location of spacings study areas in Montana and Idaho.

RESULTS AND DISCUSSION

Results of the basal live limbs study and the fill-in regeneration study are discussed separately.

Height to Lowest Live Limb Relationships

Age (AGE), stand density (SD), and tree height (TH) were each significantly related ($p = 0.001$) to the height of the lowest live limb (HLLL) of study trees. The linear regression equation:

$$HLLL = 0.0068 + 0.00114 (AGE \times SD) + 0.0904 TH$$

explained 62 percent of the variation in the height to lowest live limb among study trees. The standard error of the estimate for this equation was 0.21 ft. Scatter plots of residuals over predicted values of height to lowest live limb and of residuals over regressor variables showed no abnormalities in the least squares fitting of the data. Accordingly, the model was adopted as a reasonable representation of the height of the lowest live limb in relation to the concomitant variable, tree height, and to the interaction of tree age and stand density. To illustrate the model relationships, the equation was solved for sets of values thought to be representative of young stands commonly considered for thinning. The results were plotted in a series of three-dimensional bar graphs, representing the height of the lowest live limb, at 4-year intervals from 8 to 28 years of age (fig. 2).

Because live limbs can develop into leaders if left on stumps, the expected height to the lowest live limb should be considered when deciding the right time to thin lodgepole pine stands. Figure 2 should help managers identify ages for initial thinnings that minimize the problem of leaders developing on stumps. A heavy line is drawn across the face of transition bars at 0.5 ft in each graph to show the point at which leaders would no longer be a problem if stumps were cut this low during thinning. Bars to the left or to the front of these bars represent combinations of stocking level and tree height expected to have live limbs below 0.5 ft.

Figure 2 suggests managers should avoid thinning lodgepole pine stands before stands are at least 8 years old. Stands near this age that have stocking levels so high that the trees are already beginning to stagnate might be exceptions. This would probably occur at

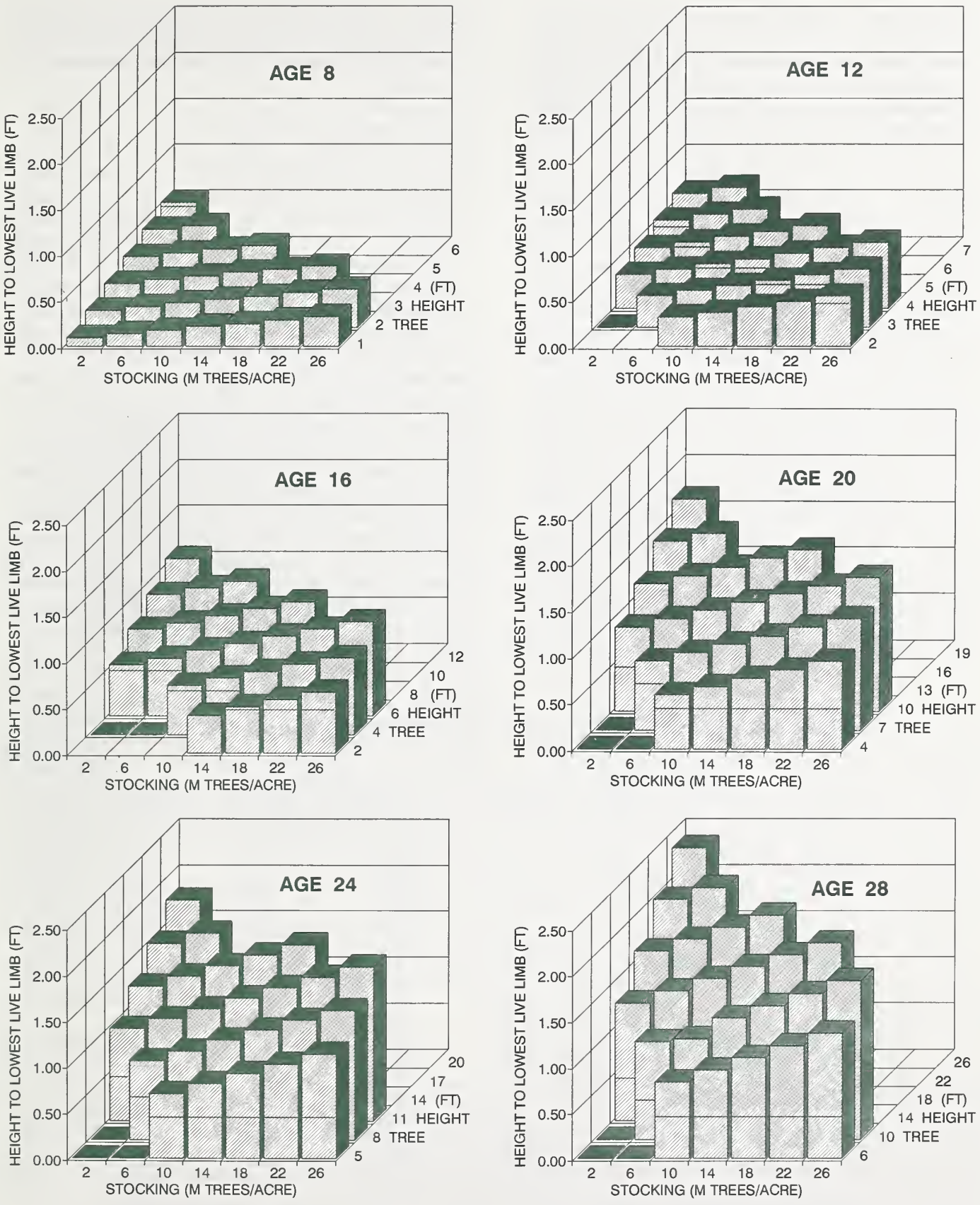

Figure 2—Effect of stand stocking and tree height on height to lowest live limb of lodgepole pine, at 4-year increments from 8 to 28 years. Lines across the face of bars represent 0.5 ft, the point at which leaders would no longer be a problem if stumps were cut this low during thinning.

stocking levels beyond 20,000 trees per acre (Johnson 1985). At age 12, stands with stocking levels beyond 14,000 trees per acre could be thinned without a high proportion of stumps having live branches that might become leaders. At such high stocking levels, some of the shortest trees are likely to have live limbs below 0.5 ft at age 12. These short trees are likely to be quite low in vigor. Limbs left on their stumps aren't likely to develop into leaders. Conversely, when 12-year-old stands stocked at less than 10,000 to 14,000 trees per acre are thinned, limbs left on the stumps of shorter trees are more likely to develop into leaders. By age 16, the height of the lowest live limbs is above 0.5 ft for almost all stocking and height classes likely to be thinned. Although the lowest limbs are more likely to be above 0.5 ft as stands get even older, significant growth would probably be lost if thinning were delayed this long in stands stocked much beyond several thousand trees per acre (Johnstone 1985; Lotan and Critchfield 1990). This effect is mediated by site quality: the higher the site quality, the later growth would be lost and the less growth would be lost from a given level of overstocking (Cole and Edminster 1985).

The problem of live limbs on stumps becoming leaders seems to have been greater on the Lewis and Clark and Bitterroot National Forests than on the Gallatin National Forest. The respective roles of thinning prescriptions and possible genetic differences in the perceived difference is unknown; however, the uncertainty suggests that results and guidelines based on the model be tempered with local observations and experience.

Fill-in Regeneration

The amount of fill-in regeneration increased with spacing levels at all four locations observed (table 1). However, a difference was noted in the time at which spacing had its greatest influence for the Lewis and Clark, Gallatin, and Targhee National Forest locations: during the final 6 years of the 17-year study, seedling establishment declined at the narrowest spacing and increased at the widest. The most striking difference was noted at the Targhee National Forest site where an average of eight times as many seedlings became established during the last 6 years of the study as during the first 10 years for the three widest spacings. The number of seedlings established during the final 6 years was twice as much as during the first 10 years for the Lewis and Clark National Forest and three times as much for the Gallatin National Forest. These differences might be related to differences in the ratio of nonserotinous to serotinous cones noted to occur at different locations (Lotan 1975; Muir and Lotan 1985), or to other differences of the sites. Lodgepole pine's propensity to become established varies locally and

Table 1—Fill-in regeneration following spacing of sapling lodgepole pine

Location	Year of origin	Year spaced	Spacing level	Regeneration by period		
				1975-85	1986-91	1975-91
			Feet	*Trees/acre*		
Lewis and Clark NF	1955	1965	6x6	232	18	250
			9x9	205	54	259
			12x12	333	591	924
			15x15	198	1,053	1,251
			18x18	766	977	1,743
Gallatin NF	1954	1967	6x6	268	36	304
			9x9	143	215	358
			12x12	323	301	624
			15x15	393	344	737
			18x18	373	515	888
Targhee NF	1958	1966	6x6	107	36	143
			9x9	116	259	375
			12x12	640	1,038	1,678
			15x15	274	1,393	1,667
			18x18	135	2,284	2,419
Kootenai NF	1973	1973	6x6			36
			9x9			134
			12x12			500
			15x15			624
			18x18			713

geographically according to differences in ecological habitats (Fiedler 1990; Lotan 1975; Smithers 1961). Habitat type probably accounts for the lower levels of ingress noted at the Kootenai National Forest location. Lodgepole pine plays a minor seral successional role in the mesic habitat there. This study cannot evaluate the role of ecological habitat types, because each study location was in a different habitat type. Spacing-influenced differences between the locations might have been due to factors other than the ecological habitat type.

The increases in establishment during the final 6 years for thinnings with wider spacings may be largely due to the noticeably greater supply of nonserotinous cones we observed during each successive 5-year period of the long-term parent study. Favorable seedbeds continued to be available at the wider spacings, but not at tighter spacings. Apparently, these factors combined to produce the dramatic increase in seedlings at the Targhee National Forest site. Seedlings that become established late in stands thinned at wider spacings should not affect crop trees for some years. Many seedlings, especially those closer to crop trees, may not survive long, since they are likely to have low vigor. However, enough of the fill-in regeneration may survive to compromise long-term spacing objectives, if it is not removed.

Fill-in regeneration apparently ceased to be a problem 15 years after thinning in stands thinned to 6- by 6-ft spacings. This marked decline in seedling establishment is consistent with several other indicators of complete stand closure (death of lower branches, cessation of lateral crown extension, and decline in cross-sectional increment) noted during the parent spacing study. These indicators also portend stand closure in the next few years in stands thinned to 9- by 9-ft spacings. Considering the low vigor of most seedlings established in the 9- by 9-ft spacings from 1986 to 1991, fill-in regeneration can probably be ignored in the 9- by 9-ft spacings after about 25 years because its effect on crop trees is likely to be inconsequential. However, if effective crop-tree spacing is to be maintained, early fill-in regeneration in 6- by 6-ft spacings and 9- by 9-ft spacings should be removed.

SUMMARY AND CONCLUSIONS

The height of the lowest live limb of young lodgepole pine trees was found to be significantly related to tree age and height, and to stand density. A linear regression model incorporating these relationships explained 62 percent of the variation in the height to the lowest live limb of 94 study trees in three regenerated clearcuts in the Gallatin National Forest. Graphs based on the model show how long after thinning managers should wait to prevent leaders from developing from live limbs left on the stumps of thinned trees. The graphs show when the basal limbs are likely to have grown more than 0.5 ft from the ground, depending on stocking. The lowest stump that is practical during thinning is 0.5 ft. Allowing for expected variation in the age of trees in naturally regenerated lodgepole pine stands and the possibility of variation from site to site and genetic differences, the graphs should help managers interpret local data and experience.

The overall amount of fill-in regeneration following thinning increased with spacing levels at all four locations over the 17 years studied. In the last 6 years, however, seedling establishment declined at the narrowest spacing and increased at the widest. Recent increases in seedling establishment in thinnings with 18- by 18-ft spacings were from one to eight times as much as during the first 10 years of the study, probably because of continuing availability of favorable seedbeds and greater production of nonserotinous cones as the trees approach the small pole stage. Seed from nonserotinous cones in mature stands adjacent to the thinning areas was not thought to be a factor; however, where seedwalls are directly adjacent, additional seedling establishment could be expected from this seed source. Fill-in regeneration capable of compromising the 6- by 6-ft and 9- by 9-ft spacings only occurred during the first 15 years after thinning. At spacings much greater than 9- by 9-ft fill-in regeneration requiring removal will probably occur for 25 to 30 years after thinning. Three management guidelines are based on these observations:

1. Leaders are likely to develop from basal limbs on stumps and fill-in regeneration is likely to be a problem if young lodgepole pine stands are thinned before age 16 to spacings much wider than 9 by 9 ft. Leaders growing from stumps should be removed within 3 years of the initial thinning. Fill-in regeneration will probably have to be removed over a 15- to 20-year period following thinning, if growth and yield objectives are to be maintained. If growth and yield objectives are relaxed to provide hiding cover or other wildlife values, followup cleaning of the stands might not be necessary. If such wildlife values are a concern, perhaps the thinning should be delayed a few more years, or a narrower spacing should be chosen in the first place. In most cases, these considerations must be resolved on a stand-to-stand basis.

2. To avoid the increased costs of removing live limbs left on a 0.5 ft stump, stands should not be thinned before age 16 unless they exceed 10,000 to 15,000 trees per acre. Stands should not be thinned before age 12 unless they exceed 15,000 to 20,000 trees per acre. For each of these age thresholds, the lower stocking level would apply to the poorest sites, and the higher stocking level would apply to the best sites. Initial thinnings in stands younger than the above age thresholds would likely require followup to remove leaders from branches left on stumps, unless stands were

thinned by pulling excess trees by hand. The number of trees per acre that can be removed economically by pulling would normally be much fewer than can be removed by cutting. Nonetheless, if the trees are small and the stand is not too dense, hand pulling can avoid the problems of leaders growing from stumps and fill-in regeneration. Ideally, seedlings should be just tall enough to be seen easily, but young enough that roots will pull easily. Seedlings, ranging from 4 to 7 years old and 12 to 18 inches high can be pulled easily. Studies are needed to determine the upper limits of stocking that can economically be thinned by this method.

3. A two-step thinning prescription will minimize the problem of leaders growing from stumps, while maintaining hiding cover for wildlife without undue losses in growth and yield: (a) a stocking control thinning to about a 6- by 6-ft spacing (1,210 trees per acre), at an age indicated by the stocking level (see 2 above); (b) a second thinning to about 12- by 12-ft spacing (300 trees per acre), 15 to 25 years after the initial thinning. Trees cut during the second thinning could be used for fiber, firewood, or small roundwood products.

REFERENCES

Cole, D. M.; Edminster, C. B. 1985. Growth and yield of lodgepole pine. In: Lodgepole pine: the species and its management: Proceedings of symposium; 1984 May 8-10; Spokane, WA; 1984 May 14-16; Vancouver, BC. Pullman, WA: Washington State University, Cooperative Extension: 263-290.

Fiedler, Carl E. 1990. Natural regeneration following clearcutting in the spruce-fir zone of western Montana. Minneapolis, MN: University of Minnesota. 170 p. Dissertation.

Johnson, Ralph. 1985. Stocking guides for lodgepole pine using the stand prognosis model. In: Lodgepole pine: the species and its management: Proceedings of symposium; 1984 May 8-10; Spokane, WA; 1984 May 14-16; Vancouver, BC. Pullman, WA: Washington State University, Cooperative Extension: 233-238.

Johnstone, Wayne D. 1985. Thinning lodgepole pine. In: Lodgepole pine: the species and its management: Proceedings of symposium; 1984 May 8-10; Spokane, WA; 1984 May 14-16; Vancouver, BC. Pullman, WA: Washington State University, Cooperative Extension: 253-262.

Lotan, James E. 1975. The role of cone serotiny in lodgepole pine forests. In: Management of lodgepole pine ecosystems: Proceedings of symposium; 1973 October 9-11; Pullman, WA. Pullman, WA: Washington State University: 471-495.

Lotan, J. E.; Critchfield, W. B. 1990. *Pinus contorta* Dougl. ex Loud. Lodgepole pine. In: Burns, R. M.; Honkala, B. H., tech. coords. Silvics of North America. Vol. 1, Conifers. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service: 302-315.

Muir, J. E.; Lotan, J. E. 1985. Serotiny and life history of *Pinus contorta* var. *latifolia*. Canadian Journal of Botany. 63: 938-945.

Pfister, R. D.; Kovalchik, B. L.; Arno, S. F.; Presby, R. C. 1977. Forest habitat types of Montana. Gen. Tech. Rep. INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 174 p.

Smithers, L. A. 1961. Lodgepole pine in Alberta. Bull. 127. Ottawa, ON: Canadian Department of Forestry. 153 p.

Steele, R.; Cooper, S. V.; Ondov, D. M.; Roberts, D. W.; Pfister, R. D. 1983. Forest habitat types of eastern Idaho-western Wyoming. Gen. Tech. Rep. INT-144. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 122 p.

Cole, Dennis M. 1993. Problems in lodgepole pine thinnings: basal live limbs and fill-in regeneration. Res. Pap. INT-466. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 6 p.

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KEYWORDS: *Pinus contorta*, thinning, timber stand improvement, ingress, spacing, western Montana, eastern Idaho

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